Atty Dkt. No.   NVDA P000605 US
U.S. Serial No.   Unkown
Filed: Herewith
Applicant: Maufer et al.
Title: DATA STRUCTURES AND STATE TRACKING
FOR NETWORK PROTOCOL PROCESSING
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ADDRESS TRANSLATION
FLOW
100

PACKET
INTERROGATION
FLOW
120

NPU MODE A FLOW
140

NPU MODE B FLOW
160

COMPOSE PACKET
FLOW
180

FIG. 1

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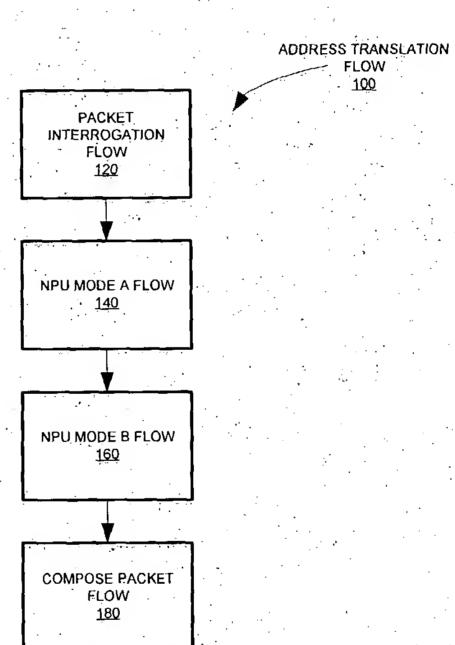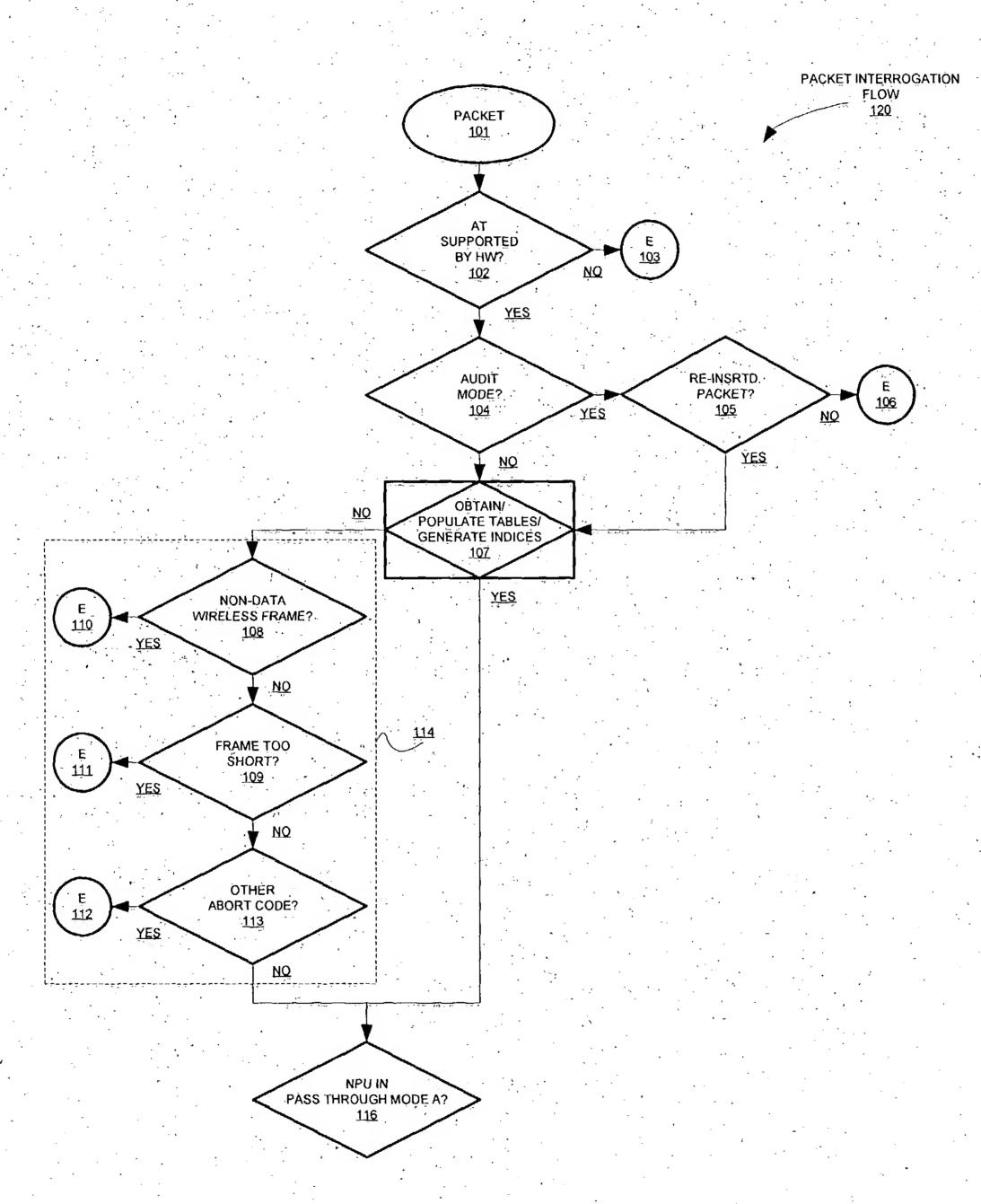Express Mail No.:   EV 324942700 US
Page 2 of 25

PACKET INTERROGATION
FLOW
120

PACKET
101

AT
SUPPORTED
BY HW?
102

E
103

NO

YES

AUDIT
MODE?
104

YES

RE-INSRTD
PACKET?
105

NO

E
106

NO

YES

NO

OBTAIN/
POPULATE TABLES/
GENERATE INDICES
107

YES

NON-DATA
WIRELESS FRAME?
108

E
110

YES

NO

114

FRAME TOO
SHORT?
109

E
111

YES

NO

OTHER
ABORT CODE?
113

E
112

YES

NO

NPU IN
PASS THROUGH MODE A?
116

FIG. 2A-1

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WIRELESS
FLOW
118

NON-DATA
WIRELESS FRAME?
108

NO → E
110

YES

DID THE FRAME
COME FROM THE HOST?
115

NO → E
117

YES

TRANSMIT PACKET
157

FIG. 2A-2

Atty Dkt. No.   NVDA P000605 US
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Filed: Herewith
Applicant: Maufer et al.
Title: DATA STRUCTURES AND STATE TRACKING
FOR NETWORK PROTOCOL PROCESSING
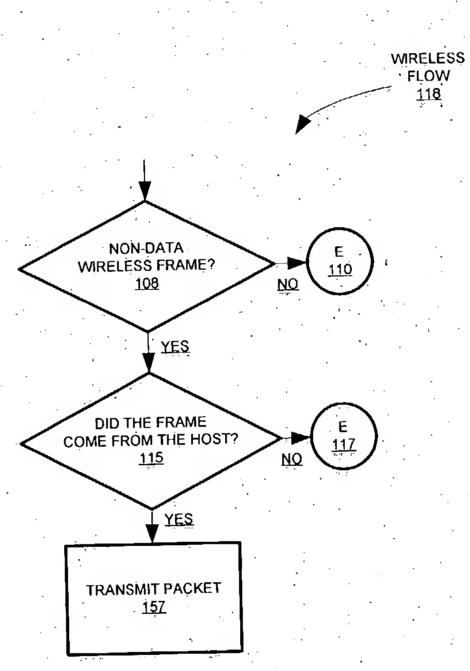Express Mail No.:   EV 324942700 US
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FIG. 2B-1

Atty Dkt. No.   NVDA P000605 US
U.S. Serial No.   Unkown
Filed: Herewith
Applicant: Maufer et al.
Title: DATA STRUCTURES AND STATE TRACKING
FOR NETWORK PROTOCOL PROCESSING
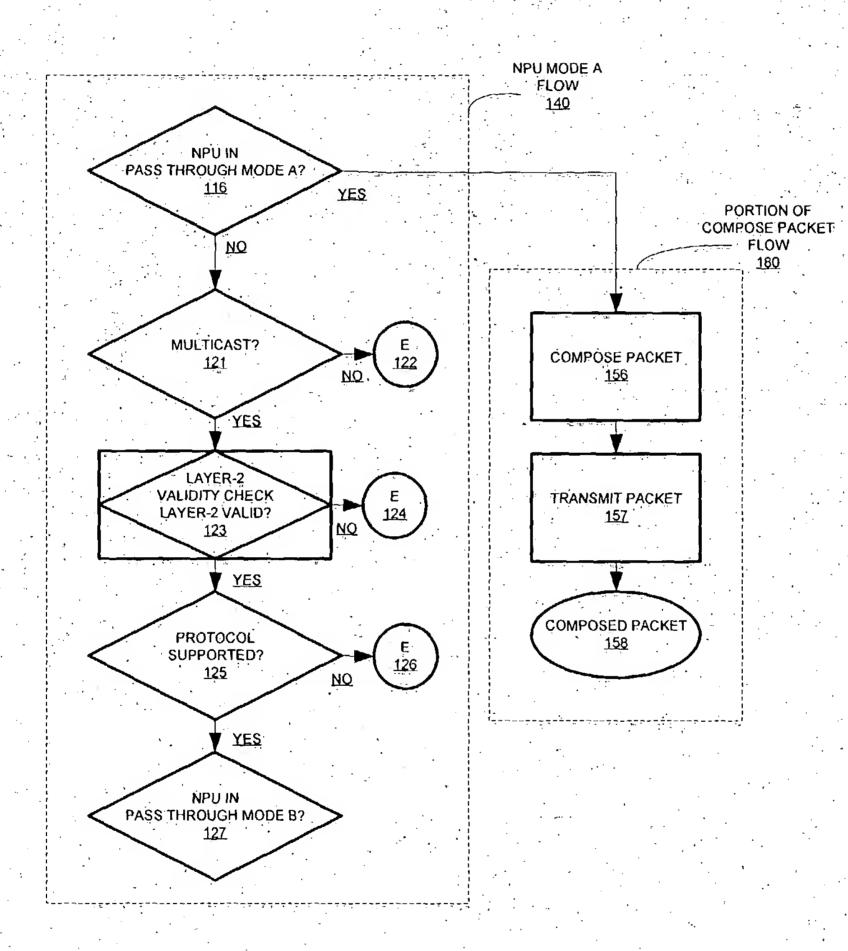Express Mail No.:   EV 324942700 US
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FIG. 2B-2

NPU MODE B
FLOW
160

NPU IN
PASS THROUGH
MODE B?
127
YES

NO

LOOK UP MAC
SOURCE ADDRESS/
IN TABLE?
131   NO → E 132

YES

CONTROL
BITS READ?
134   NO → E 135

YES

IIF RUNNING NAT?
136   YES → NAT FILTERING 137

NO

BRIDGING AND
ROUTING
138

E 142 ← NO — FRAME
REPLICATION.
SUPPORTED IN HW?
141   YES ← MULTICAST
OR BROADCAST FRAME?
139

YES   NO   146

E 144 ← YES — EXPANSION
OR SKIPPING?
143   NO → OIF = IIF?
145   YES → E 147

NO

TYPE
AND PROTOCOL
SUPPORTED
ON OIF?
148   NO → E 149

YES

BROADCAST
OR MULTICAST
ON OIF?
151   NO → E 152

YES

NON-IP PROTOCOL?
153

FIG. 2C

Atty Dkt. No.   NVDA P000605 US
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Express Mail No.:   EV 324942700 US
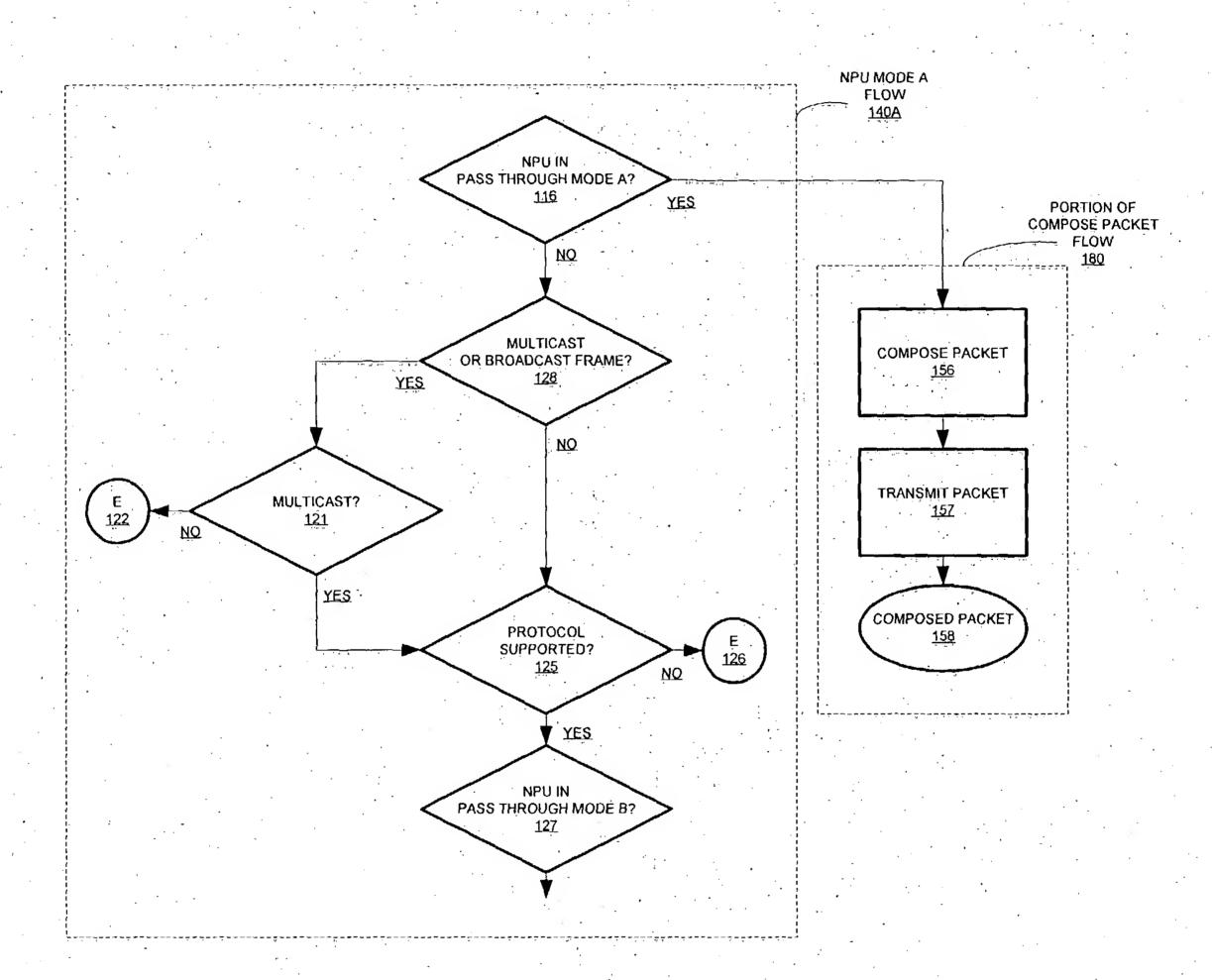Page 7 of 25
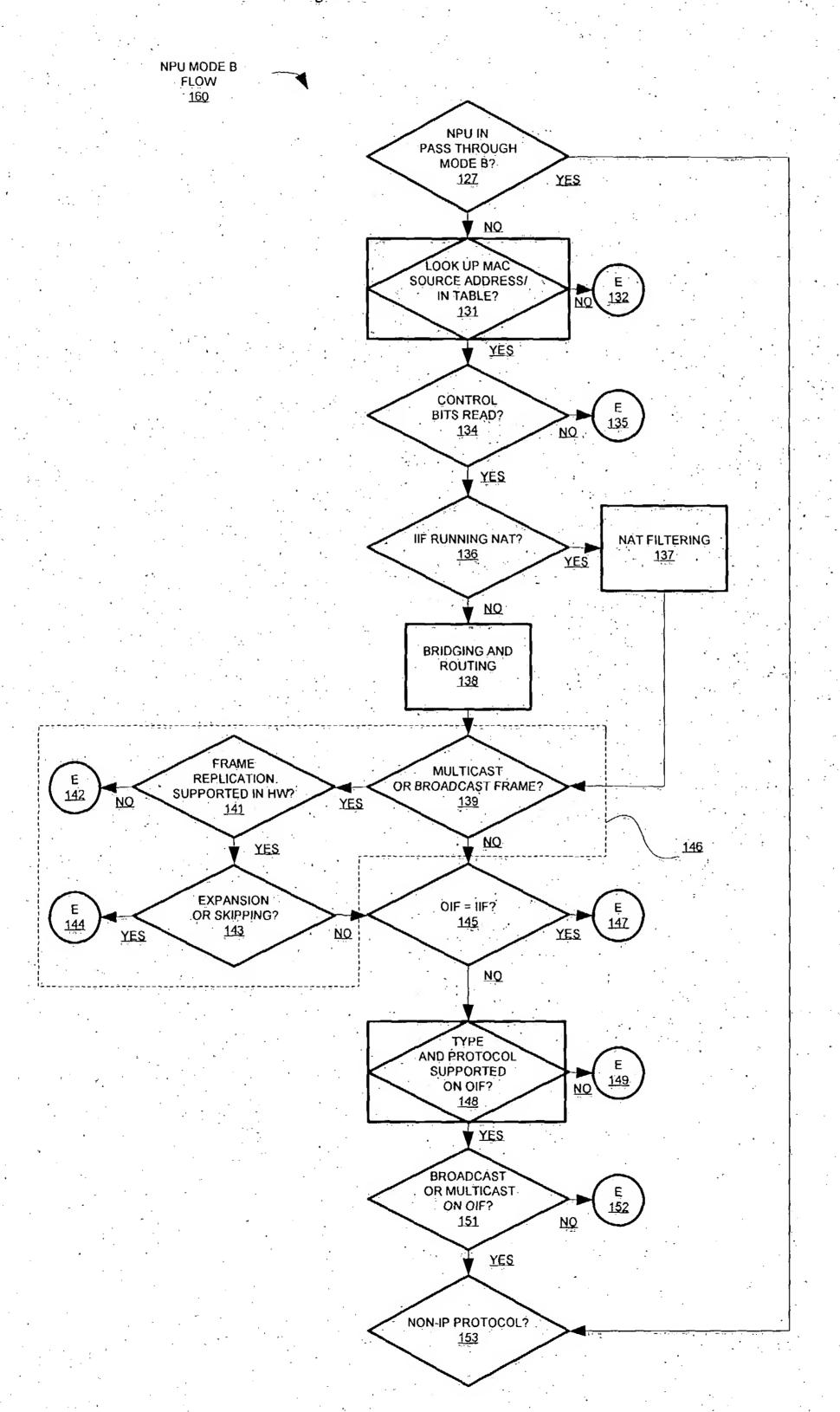
COMPOSE PACKET
FLOW
180

```
              IP PROTOCOL?
                  153                  NO
                  |
                 YES
                  |
                  v
OUTBOUND         IIF AND OIF
FILTERING        BOTH TRUSTED OR
   155     NO    UNTRUSTED?
                    154
                  |
                 YES
                  |
                  v
              COMPOSE PACKET
                  156
                  |
                  v
              TRANSMIT PACKET
                  157
                  |
                  v
              COMPOSED PACKET
                  158
```

FIG. 2D-1

Atty Dkt. No.   NVDA P000605 US
U.S. Serial No.   Unkown
Filed: Herewith
Applicant: Maufer et al.
Title: DATA STRUCTURES AND STATE TRACKING
FOR NETWORK PROTOCOL PROCESSING
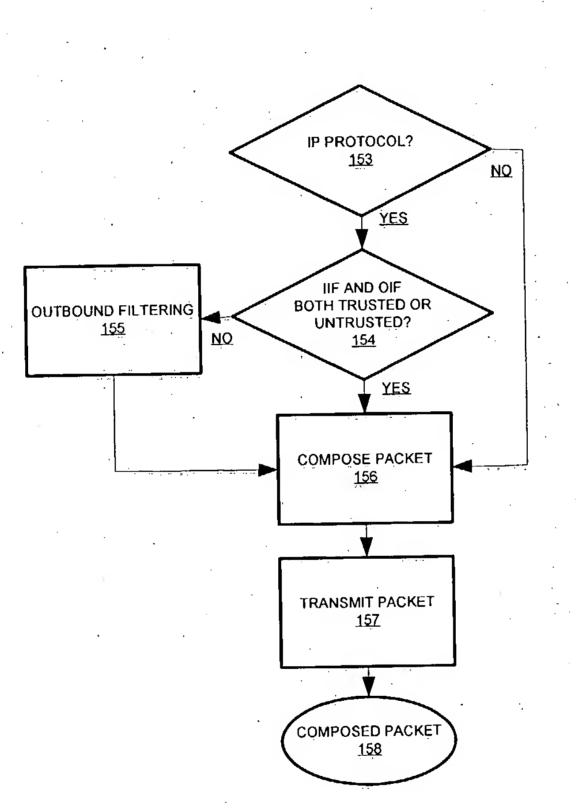Express Mail No.:   EV 324942700 US
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COMPOSE PACKET
FLOW
180A

IP PROTOCOL?
153

NO

YES

IIF AND OIF
BOTH TRUSTED OR
UNTRUSTED?
154

NO

YES

IPv6 PACKET
AND SITE BOUNDARY
ACTIVE?
201

YES

NO

PREFIXES THE SAME?
202

NO

YES

OUTBOUND FILTERING
155

COMPOSE PACKET
156

E
203

TRANSMIT PACKET
157

COMPOSED PACKET
158

FIG. 2D-2

Atty Dkt. No.   NVDA P000605 US
U.S. Serial No.   Unkown
Filed: Herewith
Applicant: Maufer et al.
Title: DATA STRUCTURES AND STATE TRACKING
FOR NETWORK PROTOCOL PROCESSING
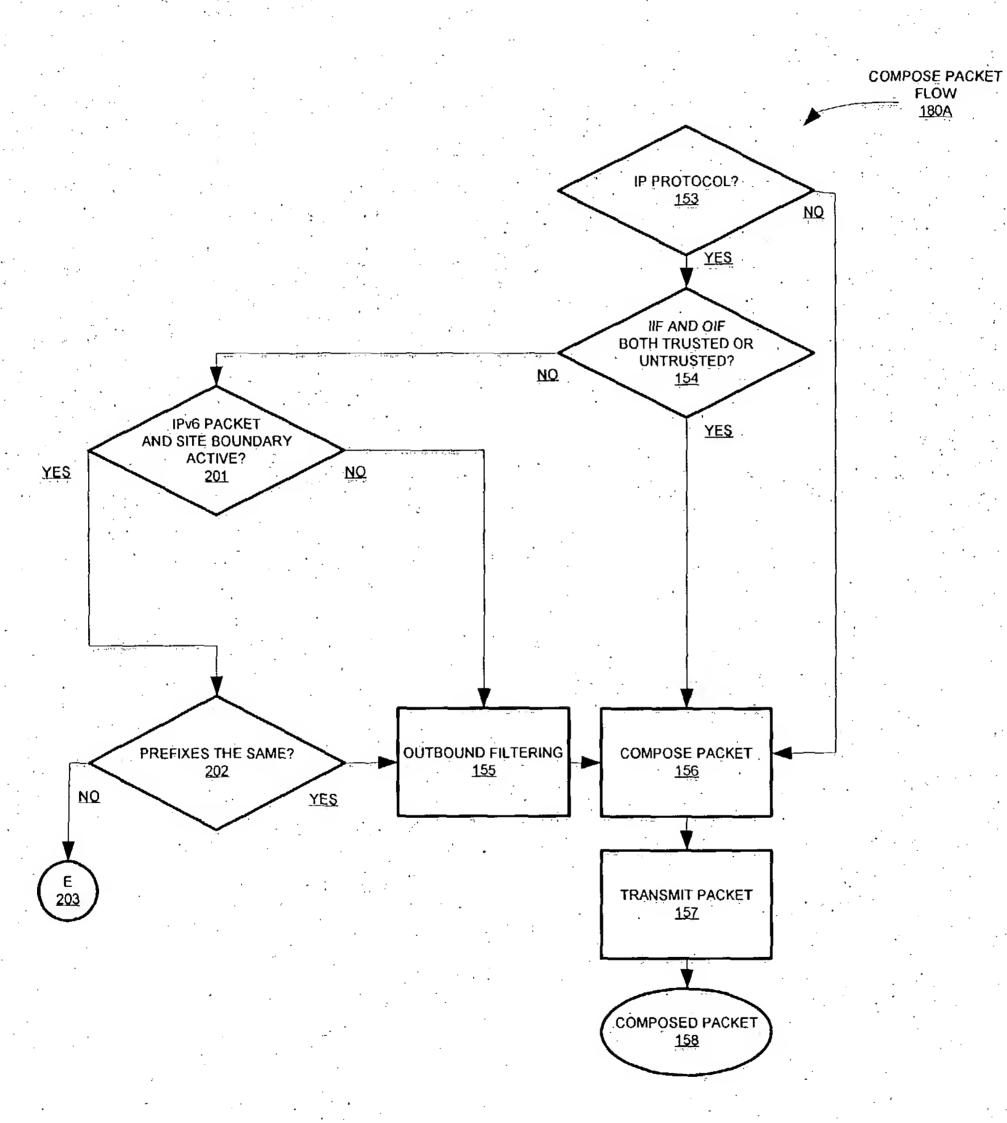Express Mail No.:   EV 324942700 US
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BRIDGING AND ROUTING
FLOW
138A

BRIDGING AND
ROUTING
301

MAC ADDRESS MATCH?
302
YES → ROUTABLE PROTOCOL?
303
NO → E 304

NO ↓

MULTICAST ROUTING
AND MULTICAST PACKET?
305
YES →

ROUTING
SUPPORTED IN HW?
306
NO → E 307

YES ↓

IP SOURCE
ADDRESS IN TABLE?
308
NO → E 313

NO ↓

E 310 ← NO ← BRIDGING
SUPPORTED IN HW?
309

YES ↓

LAYER-3 VALIDITY
CHECK AND MARK xCFH
314
NO → E 315

YES ↓

IP OPTIONS
CHECK AND MARK xCFH
316
NO → E 317

YES ↓

E 312 ← NO ← MAC
DESTINATION ADDRESS IN
TABLE AND STORE ART
311

IP
DESTINATION ADDRESS IN
TABLE AND STORE ART
318
NO → E 319

YES ↓   YES ↓
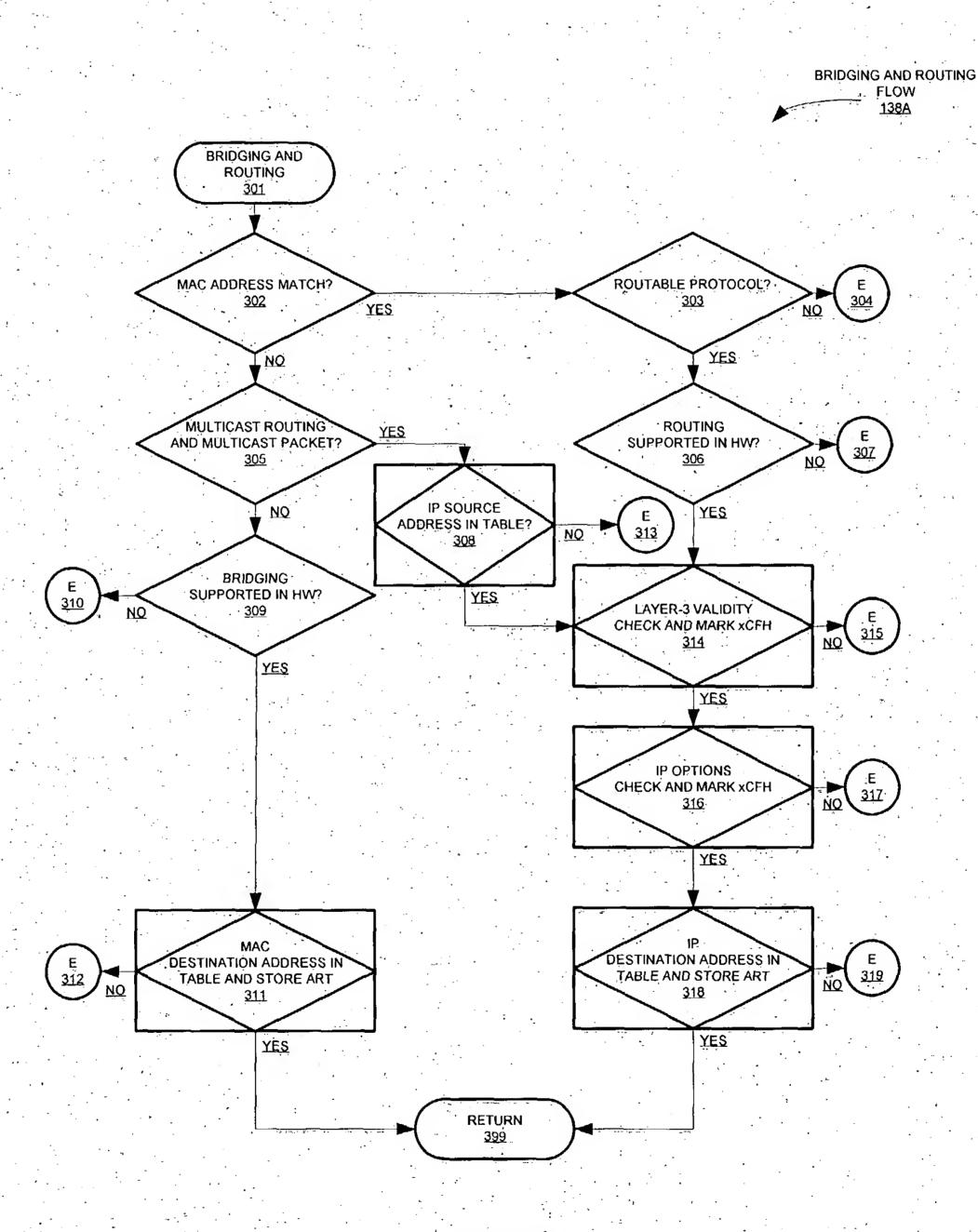
RETURN
399

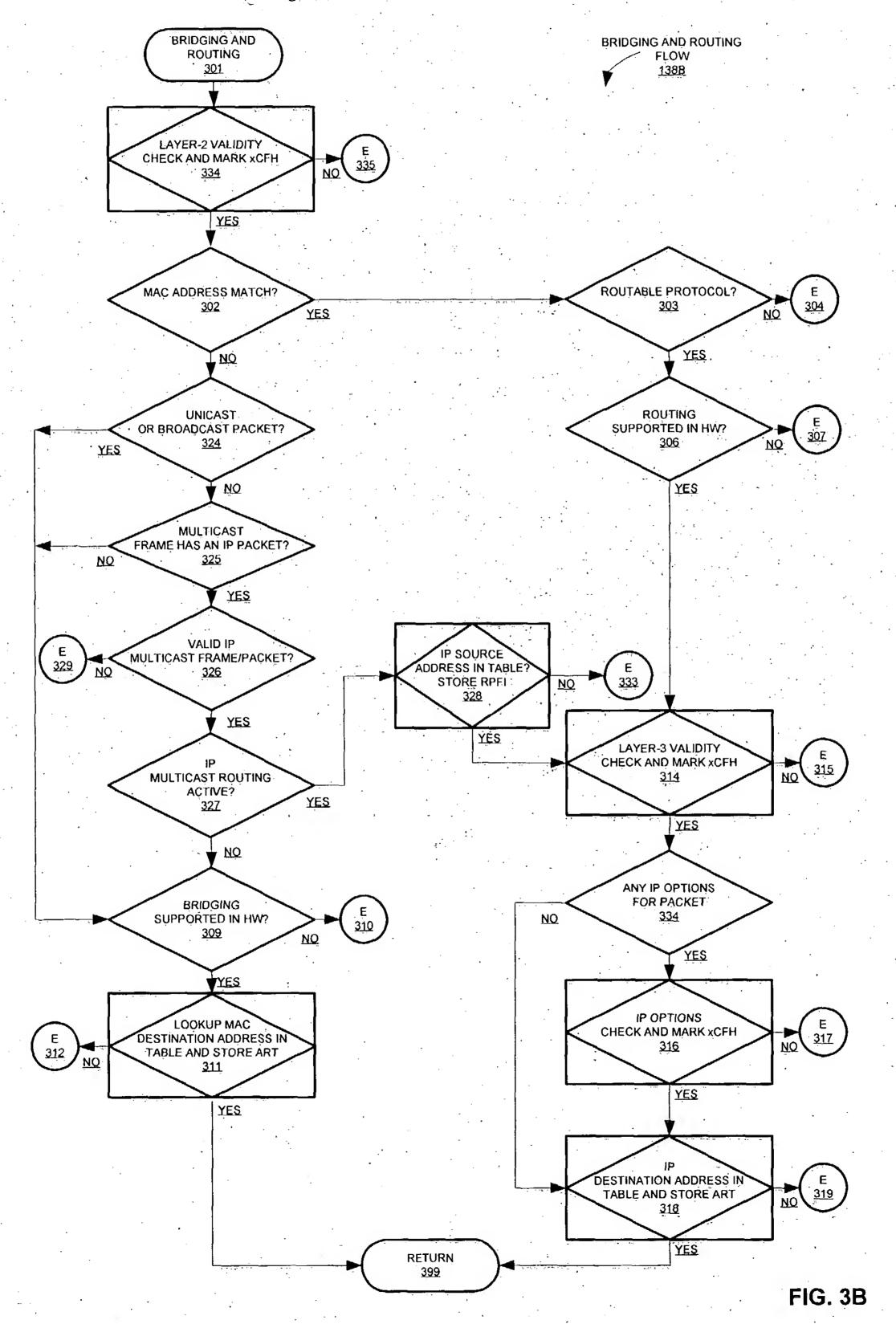**FIG. 3A**

Atty Dkt. No.   NVDA P000605 US
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FOR NETWORK PROTOCOL PROCESSING
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BRIDGING AND
ROUTING
301

BRIDGING AND ROUTING
FLOW
138B

LAYER-2 VALIDITY
CHECK AND MARK xCFH
334

NO → E 335

YES

MAC ADDRESS MATCH?
302

YES → ROUTABLE PROTOCOL?
303

NO → E 304

NO

YES

UNICAST
OR BROADCAST PACKET?
324

ROUTING
SUPPORTED IN HW?
306

NO → E 307

YES

YES

NO

YES

MULTICAST
FRAME HAS AN IP PACKET?
325

NO

YES

VALID IP
MULTICAST FRAME/PACKET?
326

NO → E 329

IP SOURCE
ADDRESS IN TABLE?
STORE RPFI
328

NO → E 333

YES

YES

IP
MULTICAST ROUTING
ACTIVE?
327

YES

LAYER-3 VALIDITY
CHECK AND MARK xCFH
314

NO → E 315

YES

NO

ANY IP OPTIONS
FOR PACKET
334

NO

YES

BRIDGING
SUPPORTED IN HW?
309

NO → E 310

YES

IP OPTIONS
CHECK AND MARK xCFH
316

NO → E 317

YES

LOOKUP MAC
DESTINATION ADDRESS IN
TABLE AND STORE ART
311

E 312 ← NO

YES

IP
DESTINATION ADDRESS IN
TABLE AND STORE ART
318

NO → E 319

YES

RETURN
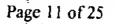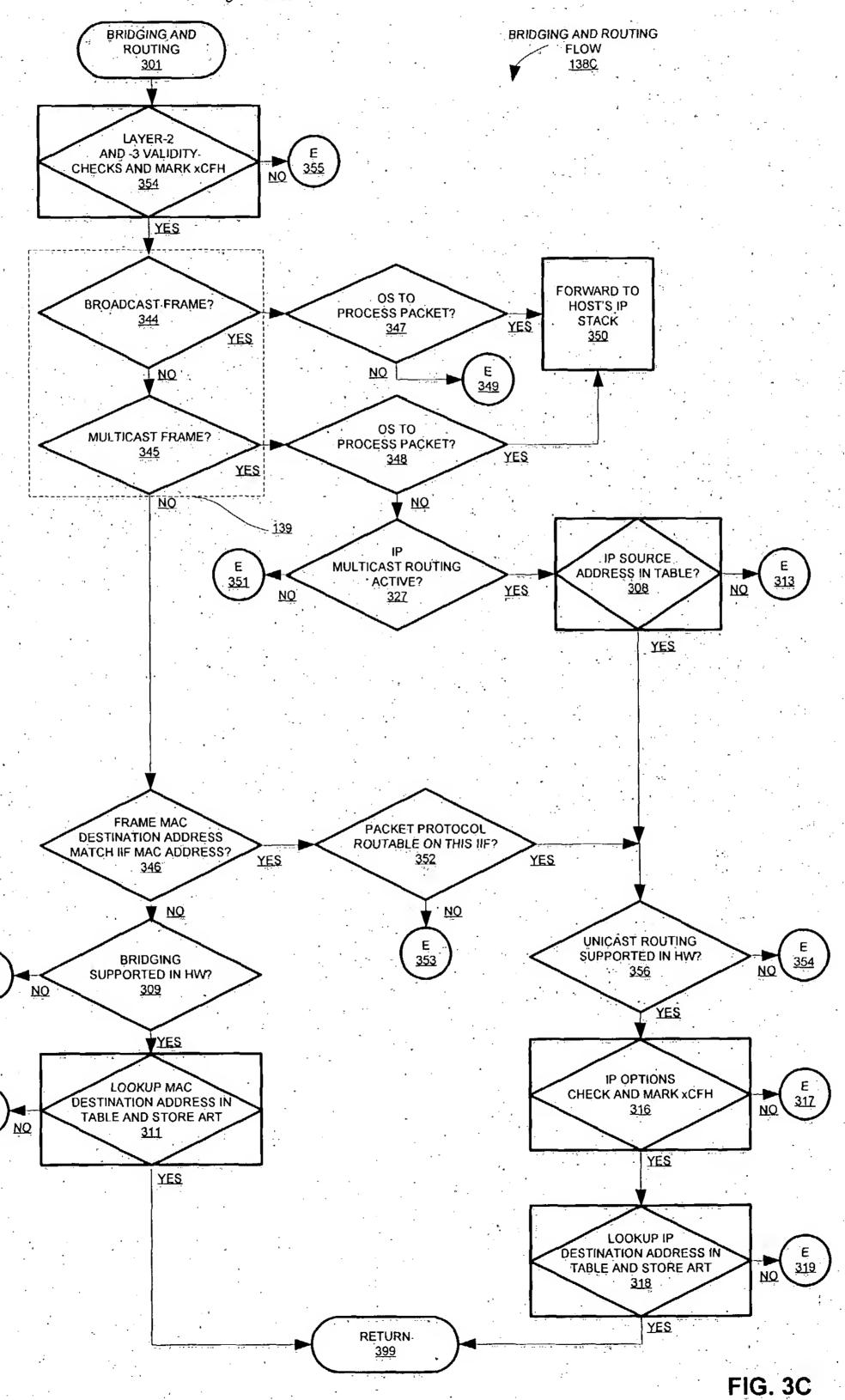399

FIG. 3B

Atty Dkt. No.   NVDA P000605 US
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BRIDGING AND
ROUTING
301

BRIDGING AND ROUTING
FLOW
138C

LAYER-2
AND -3 VALIDITY
CHECKS AND MARK xCFH
354
NO → E 355

YES

BROADCAST FRAME?
344
YES →

OS TO
PROCESS PACKET?
347
YES →

FORWARD TO
HOST'S IP
STACK
350

NO

NO → E 349

MULTICAST FRAME?
345
YES →

OS TO
PROCESS PACKET?
348
YES →

NO

NO

139

IP
MULTICAST ROUTING
ACTIVE?
327
YES →

E 351
NO

IP SOURCE
ADDRESS IN TABLE?
308
NO → E 313

YES

FRAME MAC
DESTINATION ADDRESS
MATCH IIF MAC ADDRESS?
346
YES →

PACKET PROTOCOL
ROUTABLE ON THIS IIF?
352
YES →

NO

NO

E 353

UNICAST ROUTING
SUPPORTED IN HW?
356
NO → E 354

BRIDGING
SUPPORTED IN HW?
309
NO → E 310

YES

YES

E 312
NO ←

LOOKUP MAC
DESTINATION ADDRESS IN
TABLE AND STORE ART
311

IP OPTIONS
CHECK AND MARK xCFH
316
NO → E 317

YES

YES

LOOKUP IP
DESTINATION ADDRESS IN
TABLE AND STORE ART
318
NO → E 319

YES

RETURN
399

FIG. 3C

Atty Dkt. No.   NVDA P000605 US
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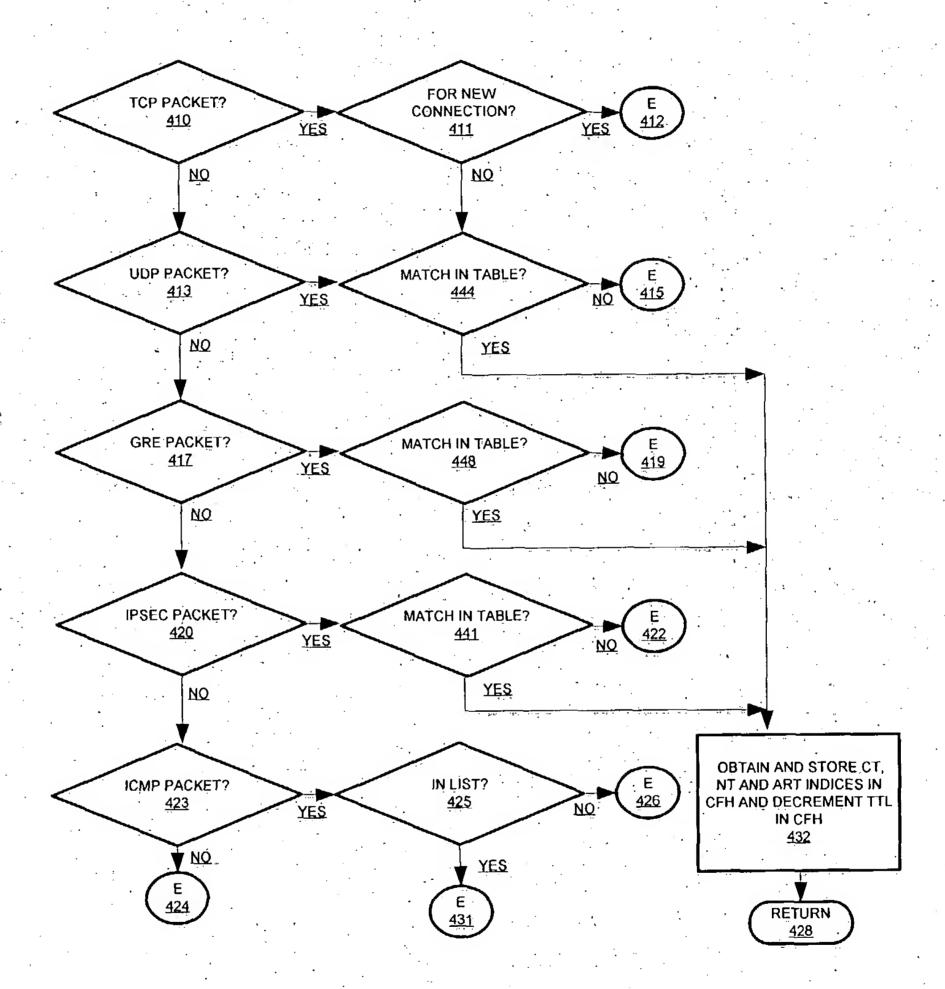Express Mail No.:   EV 324942700 US
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INBOUND NAT
(INAT) FILTERING
401

NAT FILTERING
FLOW
137

HW SUPPORT
FOR NAT?
402 — NO → E 403

YES

LAYER-2/LAYER-3
VALIDITY CHECK(S) OKAY?
404 — NO → E 405

YES

IP OPTIONS OKAY?
406 — NO → E 407

YES

IP
FRAGMENT?
408 — YES → E 409

NO

TCP PACKET?
410 — YES → FOR NEW CONNECTION? 411 — YES → E 412

NO   NO

UDP PACKET?
413 — YES → MATCH IN TABLE? STORE CT INDEX IN CFH 414 — NO → E 415

NO   YES

GRE PACKET?
417 — YES → MATCH IN TABLE? STORE CT INDEX IN CFH 418 — NO → E 419

NO   YES

IPSEC PACKET?
420 — YES → MATCH IN TABLE? STORE CT INDEX IN CFH 421 — NO → E 422

NO   YES

ICMP PACKET?
423 — YES → IN LIST? 425 — NO → E 426

NO   YES

E 424

OBTAIN AND
STORE NT
INDEX IN CFH
416

OBTAIN AND
STORE ART
INDEX IN CFH
427

RETURN
428

FIG. 4A

Atty Dkt. No.   NVDA P000605 US
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FOR NETWORK PROTOCOL PROCESSING
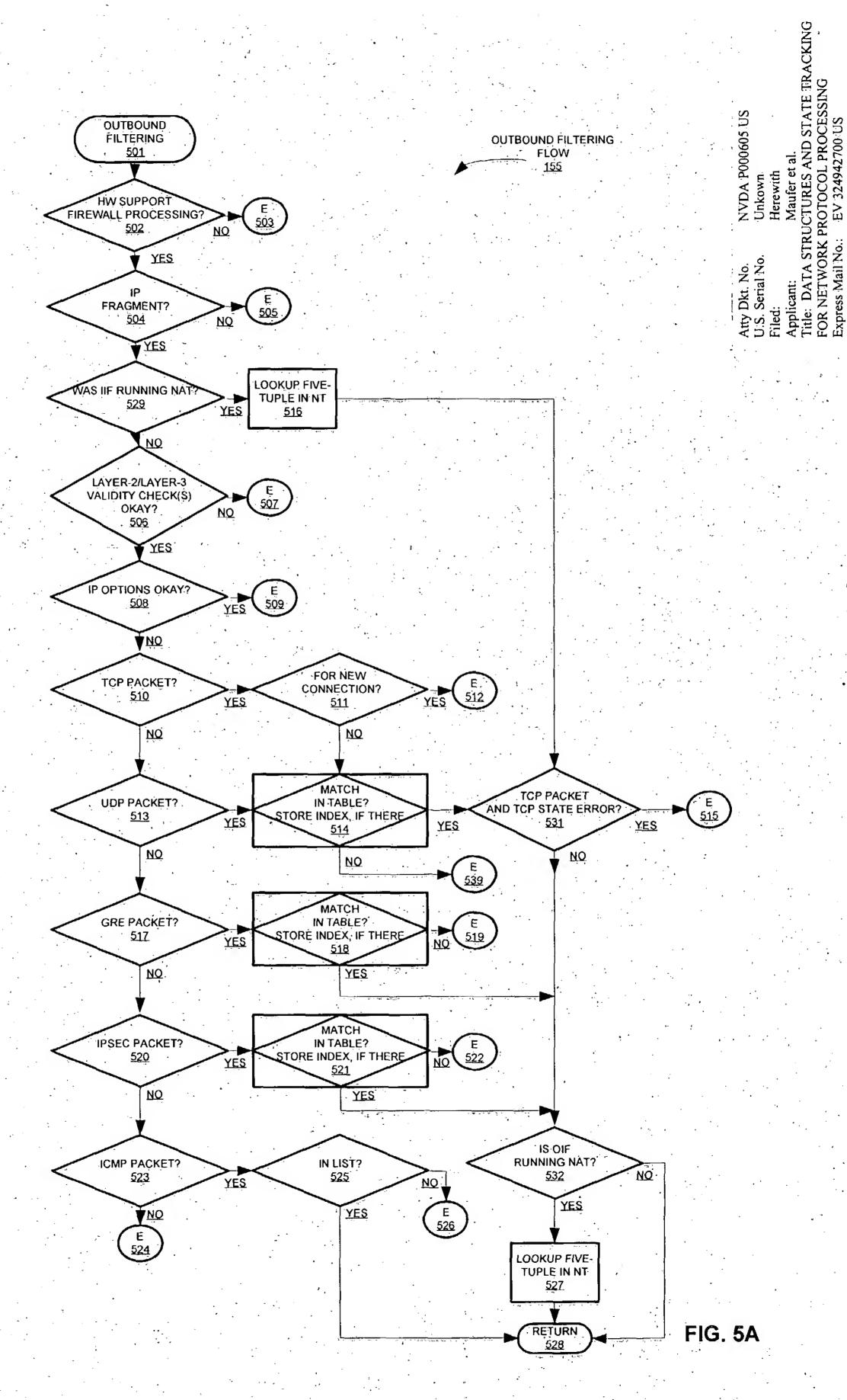Express Mail No.:   EV 324942700 US
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FIG. 4B

Atty Dkt. No.   NVDA P000605 US
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FOR NETWORK PROTOCOL PROCESSING
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OUTBOUND FILTERING
FLOW
155

```
                    ┌──────────────┐
                    │   OUTBOUND   │
                    │  FILTERING   │
                    │     501      │
                    └──────┬───────┘
                           │
                   ╱───────┴───────╲         ┌─────┐
                  ╱  HW SUPPORT     ╲   NO    │  E  │
                 ╲ FIREWALL PROCESSING?╱─────▶│ 503 │
                  ╲      502        ╱         └─────┘
                   ╲───────┬───────╱
                           │ YES
                   ╱───────┴───────╲         ┌─────┐
                  ╱      IP         ╲   NO    │  E  │
                 ╲   FRAGMENT?      ╱────────▶│ 505 │
                  ╲      504        ╱         └─────┘
                   ╲───────┬───────╱
                           │ YES
                   ╱───────┴───────╲         ┌──────────────┐
                  ╱  WAS IIF        ╲  YES    │ LOOKUP FIVE- │
                 ╲  RUNNING NAT?    ╱────────▶│ TUPLE IN NT  │
                  ╲      529        ╱         │     516      │
                   ╲───────┬───────╱          └──────────────┘
                           │ NO
                   ╱───────┴───────╲         ┌─────┐
                  ╱ LAYER-2/LAYER-3 ╲   NO    │  E  │
                 ╲ VALIDITY CHECK(S) ╱───────▶│ 507 │
                  ╲  OKAY? 506      ╱         └─────┘
                   ╲───────┬───────╱
                           │ YES
                   ╱───────┴───────╲         ┌─────┐
                  ╱ IP OPTIONS OKAY? ╲  YES   │  E  │
                 ╲      508         ╱────────▶│ 509 │
                  ╲───────┬────────╱          └─────┘
                           │ NO
```

TCP PACKET? 510 — YES → FOR NEW CONNECTION? 511 — YES → E 512

UDP PACKET? 513 — YES → MATCH IN TABLE? STORE INDEX, IF THERE 514 — YES → TCP PACKET AND TCP STATE ERROR? 531 — YES → E 515

MATCH IN TABLE? 514 — NO → E 539

GRE PACKET? 517 — YES → MATCH IN TABLE? STORE INDEX, IF THERE 518 — NO → E 519 ; YES →

IPSEC PACKET? 520 — YES → MATCH IN TABLE? STORE INDEX, IF THERE 521 — NO → E 522 ; YES →

ICMP PACKET? 523 — YES → IN LIST? 525 — NO → E 526 ; YES →

ICMP PACKET? 523 — NO → E 524

IS OIF RUNNING NAT? 532 — YES → LOOKUP FIVE-TUPLE IN NT 527 ; NO →

RETURN 528

TCP PACKET AND TCP STATE ERROR? 531 — NO →

FIG. 5A

Atty Dkt. No.   NVDA P000605 US
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FOR NETWORK PROTOCOL PROCESSING
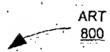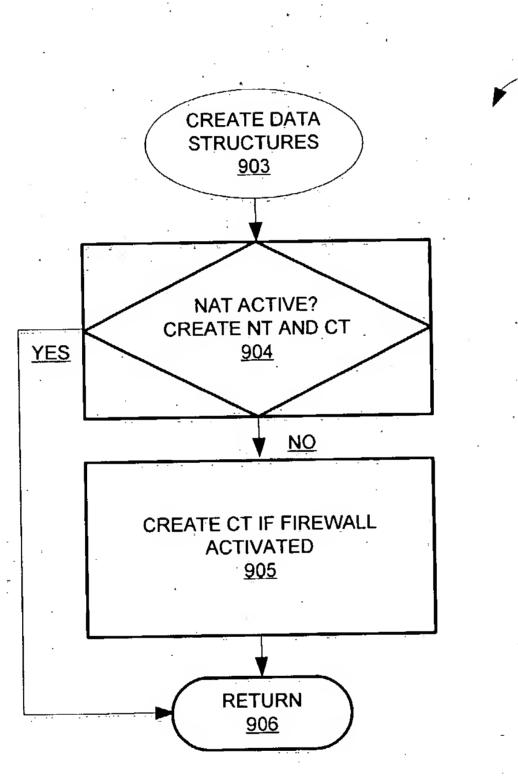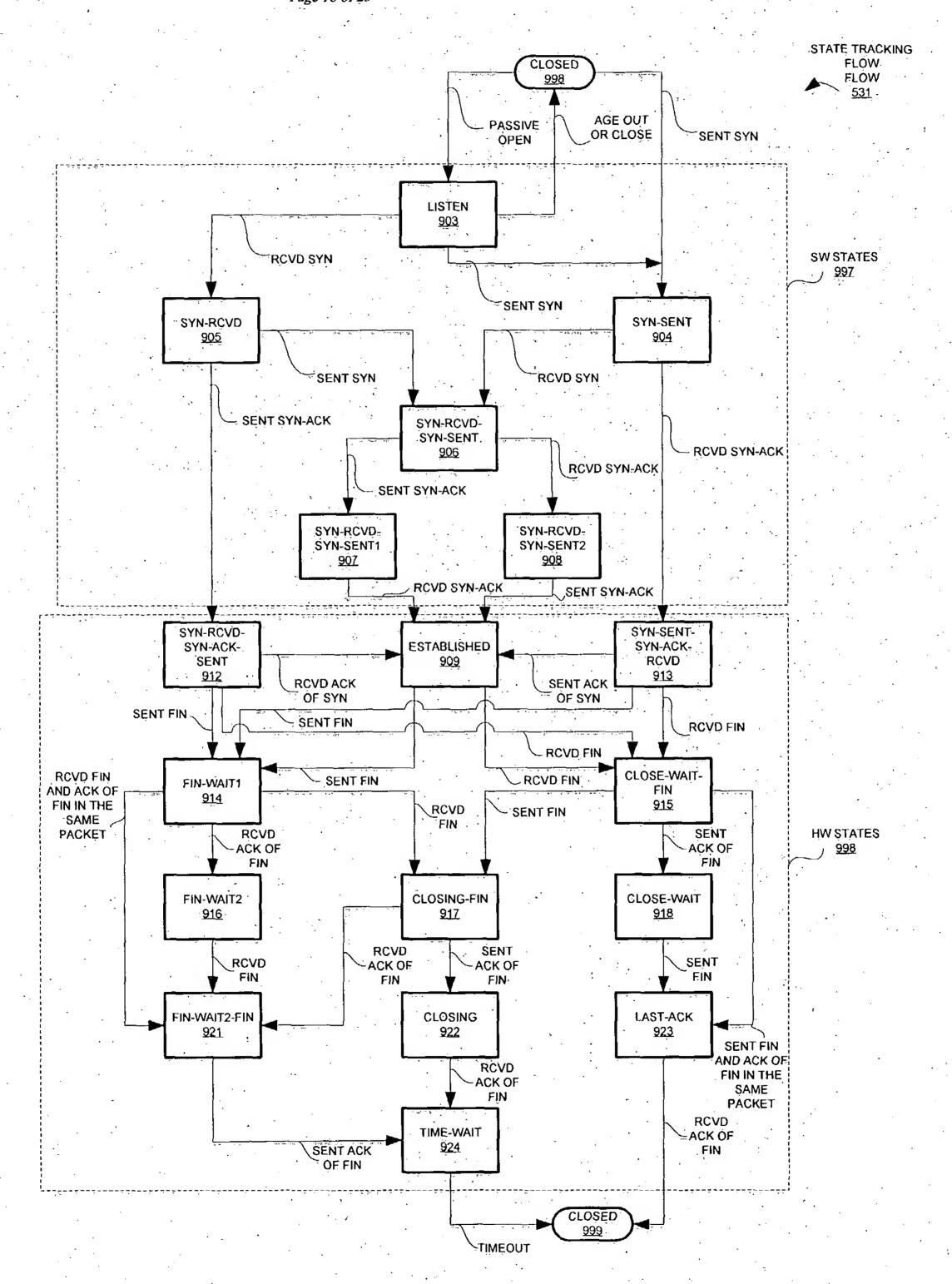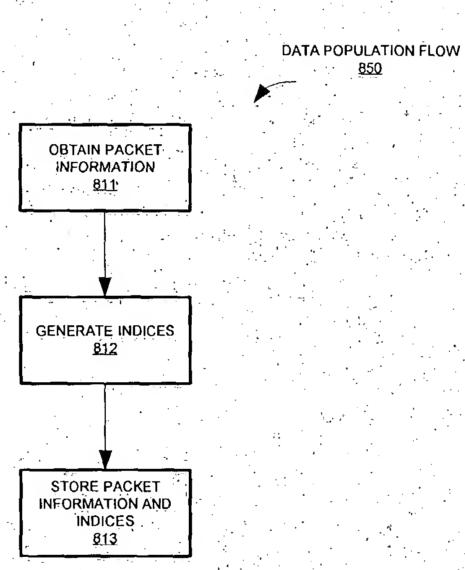Express Mail No.:   EV 324942700 US
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OUTBOUND FILTERING
FLOW
155A

OUTBOUND
FILTERING
501

HW SUPPORT
FIREWALL PROCESSING?
502 — NO → E 503

YES

WAS IIF
RUNNING NAT?
529 — NO / YES

OBTAIN CT
AND NT
INDICES FROM
CFH
566

TRANSLATE
PACKET FROM
PRIVATE TO
PUBLIC
ADDRESS
567

LAYER-2/LAYER-3
VALIDITY CHECK(S)
OKAY?
506 — NO → E 507

YES

IP OPTIONS OKAY?
508 — NO → E 509

YES

IP
FRAGMENT?
504 — YES → E 505

NO

TCP PACKET?
510 — YES → FOR NEW
CONNECTION?
511 — YES → E 512

NO

NO

UDP PACKET?
513 — YES → MATCH
IN TABLE?
STORE INDEX, IF THERE
514 — YES → TCP PACKET?
581 — NO

NO

NO → E 539

YES

TCP PACKET?
581 — YES

TCP
OPTIONS OKAY?
582 — NO → E 585

GRE PACKET?
517 — YES → MATCH
IN TABLE?
STORE INDEX, IF THERE
518 — NO → E 519

YES

YES

TCP
STATE ERROR?
583 — YES → E 584

NO

IPSEC PACKET?
520 — YES → MATCH
IN TABLE?
STORE INDEX, IF THERE
521 — NO → E 522

NO

YES

ICMP PACKET?
523 — YES → IN LIST?
525 — NO

IS OIF
RUNNING NAT?
532 — YES → LOOKUP FIVE-
TUPLE
586

NO

YES

YES → E 526

NO

TRANSLATE
PACKET FROM
PRIVATE TO
PUBLIC
ADDRESS
587

NO → E 524

RETURN
528

FIG. 5B

CT
600

ART INDEX 601	REMOTE IP ADDR 602	SPI/CALL ID 603	LOCAL IP ADDR 604	REMOTE PORT 605	NT INDEX 606	LOCAL PORT 607	IP PROTOCOL 608	TCP STATE 609	SEQ. NO. 610

FIG. 6

NT
700

ART INDEX 601	REMOTE IP ADDR 602	SPI/CALL ID 603	PUBLIC IP ADDR 704	REMOTE PORT 605	CT INDEX 706	PUBLIC PORT 707	IP PROTOCOL 608

FIG. 7

ART
800

ART INDEX 601	MAC ADDR 801	VIRTUAL LAN ID 802	INTERFACE MASK 803

FIG. 8

RT
900

IP DESTINATION ADDR 901	IP SOURCE ADDR 902	ART INDEX 601

FIG. 9A

STATE TABLE
CREATION FLOW
910

CREATE DATA
STRUCTURES
903

NAT ACTIVE?
CREATE NT AND CT
904

YES

NO

CREATE CT IF FIREWALL
ACTIVATED
905

RETURN
906

FIG. 9B

Atty Dkt. No.   NVDA P000605 US
U.S. Serial No.   Unkown
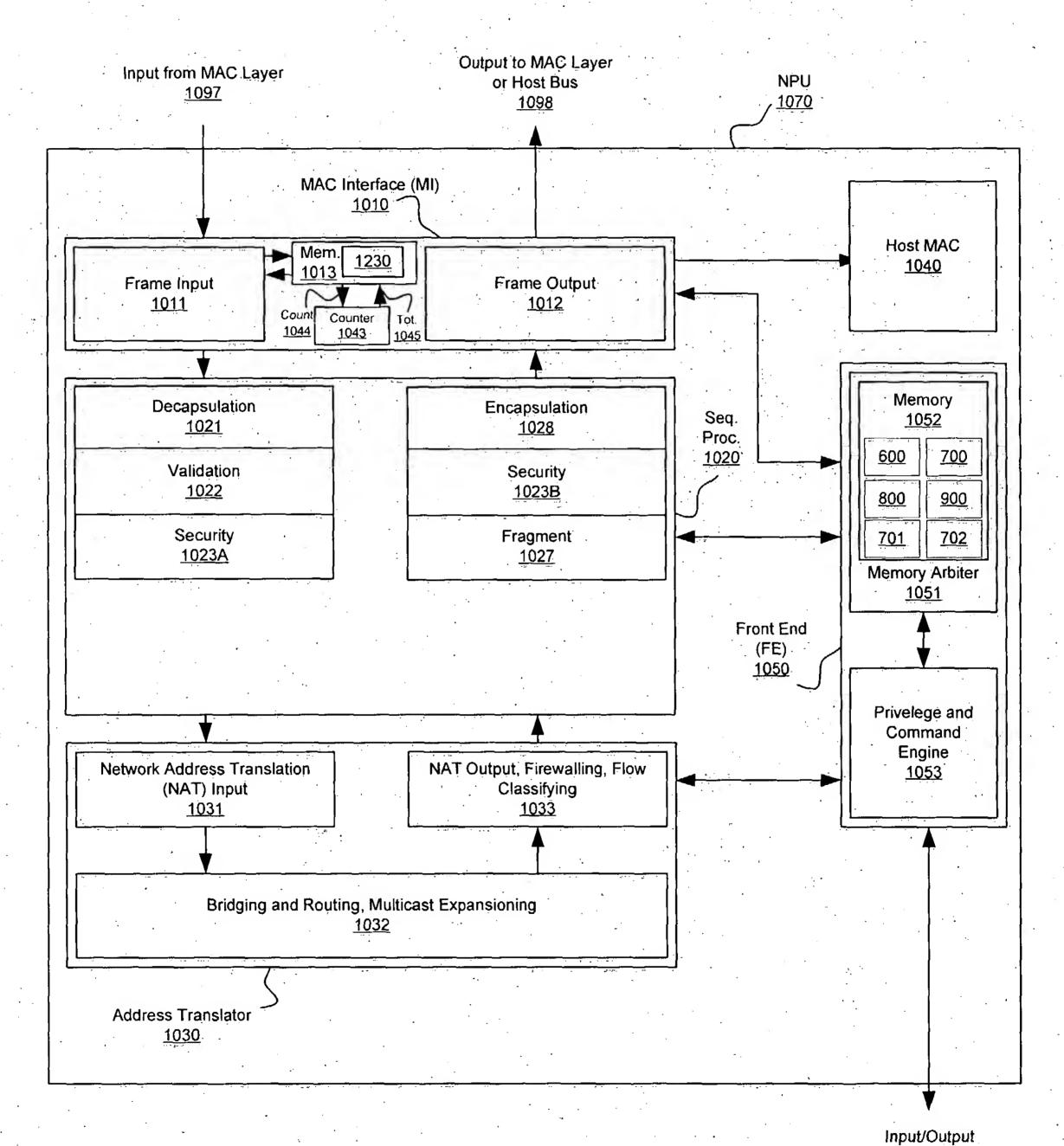Filed: Herewith
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FIG. 10

Atty Dkt. No.   NVDA P000605 US
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DATA POPULATION FLOW
850

OBTAIN PACKET
INFORMATION
811

GENERATE INDICES
812

STORE PACKET
INFORMATION AND
INDICES
813

FIG. 11

Atty Dkt. No.   NVDA P000605 US
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Filed: Herewith
Applicant: Maufer et al.
Title: DATA STRUCTURES AND STATE TRACKING
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FIG. 12A

Atty Dkt. No.   NVDA P000605 US
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Applicant: Maufer et al.
Title: DATA STRUCTURES AND STATE TRACKING
FOR NETWORK PROTOCOL PROCESSING
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PACKET PROCESSING FLOW
1080

PACKETS
1060

RECEIVE PACKETS
TO NPU AND
BUFFER PACKETS/
INCREMENT
COUNTER
1061

CHECK CT FOR AN
ENTRY FOR EACH
PACKET
1062

1081

ENTRY IN CT?
1063

NO

YES

SEND PACKET TO
NPUsoft
1064

1082

READY?
1073

NO

YES

BUILD CT ENTRY
1065

SEND
PACKET
TO
NPUsoft
1079

BUFFER PACKET
1074

OBTAIN NEXT
PACKET FROM
BUFFER
1069

PROCESS PACKET
IN SEQENCE
1066

SEND PROCESSED
PACKET TO NPU
1067

PROCESS PACKET
1075

BUFFER EMPTY?
1068

NO

YES

SET READY FLAG
ASSOCIATED WITH
CT ENTRY
1071

DECREMENT
COUNTER/
FORWARD PACKET
1072

PROCESSED
PACKETS
1076

SEND NEXT
PACKET TO NPU
1077

FIG. 12B

Atty Dkt. No.   NVDA P000605 US
U.S. Serial No.   Unkown
Filed: Herewith
Applicant: Maufer et al.
Title: DATA STRUCTURES AND STATE TRACKING
FOR NETWORK PROTOCOL PROCESSING
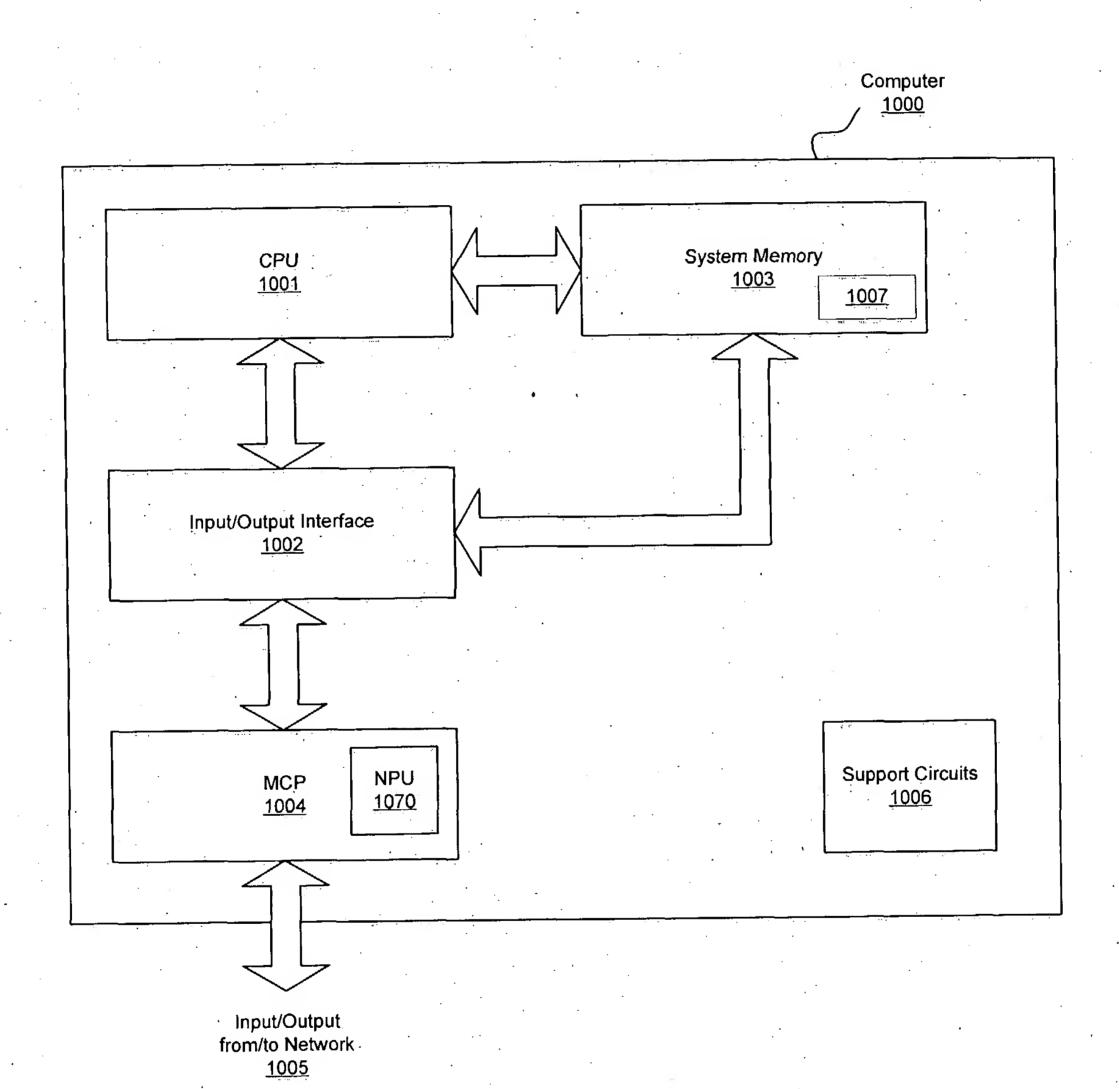Express Mail No.:   EV 324942700 US
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Computer
1000

CPU
1001

System Memory
1003

1007

Input/Output Interface
1002

MCP
1004

NPU
1070

Support Circuits
1006

Input/Output
from/to Network
1005

FIG. 13

Atty Dkt. No.   NVDA P000605 US
U.S. Serial No.   Unkown
Filed: Herewith
Applicant: Maufer et al.
Title: DATA STRUCTURES AND STATE TRACKING
FOR NETWORK PROTOCOL PROCESSING
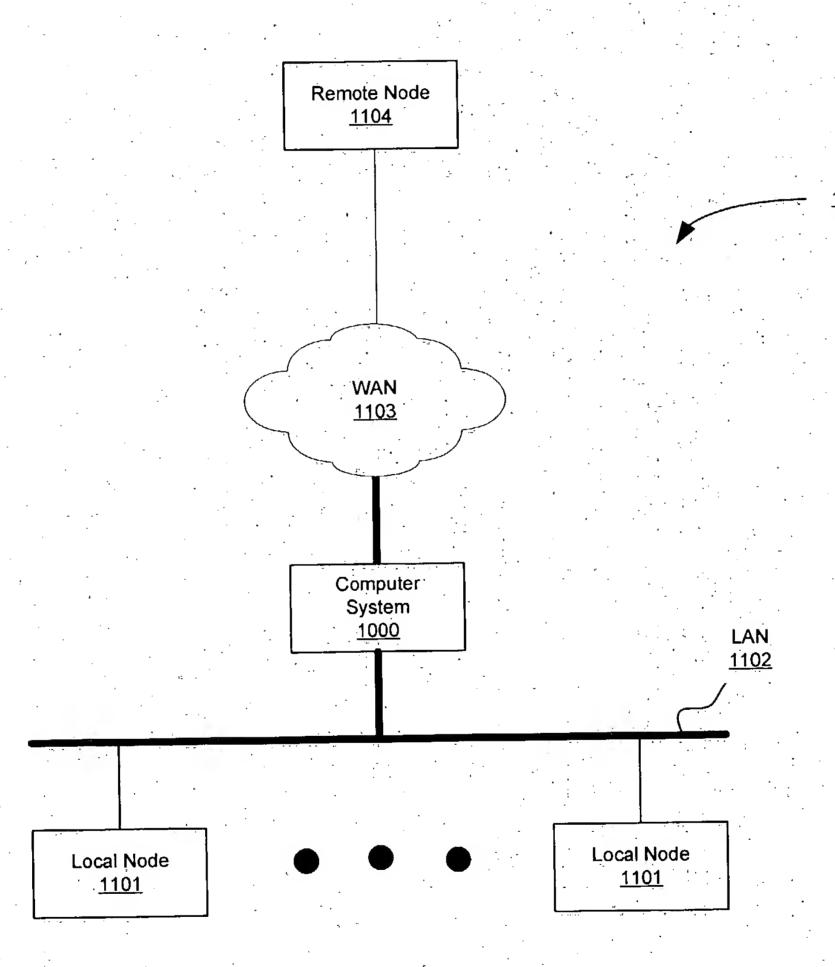Express Mail No.:   EV 324942700 US
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FIG. 14

Atty Dkt. No.   NVDA P000605 US
U.S. Serial No.   Unkown
Filed: Herewith
Applicant: Maufer et al.
Title: DATA STRUCTURES AND STATE TRACKING
FOR NETWORK PROTOCOL PROCESSING
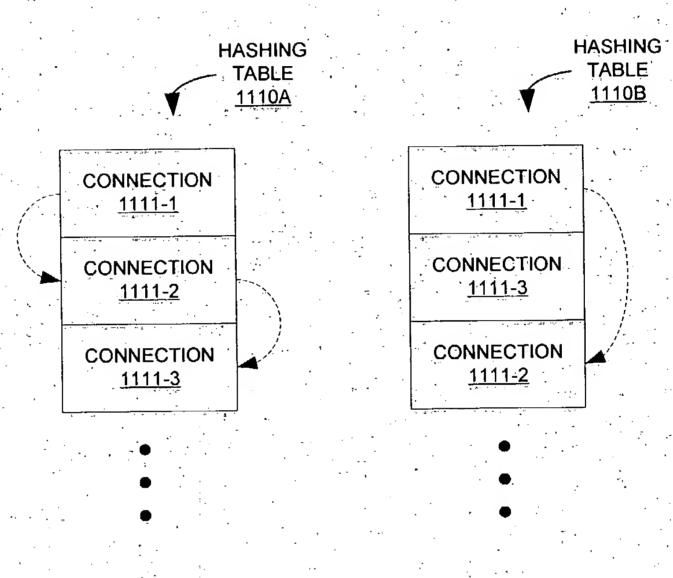Express Mail No.:   EV 324942700 US
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HASHING
TABLE
1110A

CONNECTION
1111-1

CONNECTION
1111-2

CONNECTION
1111-3

FIG. 15A

HASHING
TABLE
1110B

CONNECTION
1111-1

CONNECTION
1111-3

CONNECTION
1111-2

FIG. 15B

Atty Dkt. No.   NVDA P000605 US
U.S. Serial No.   Unkown
Filed: Herewith
Applicant: Maufer et al.
Title: DATA STRUCTURES AND STATE TRACKING
FOR NETWORK PROTOCOL PROCESSING
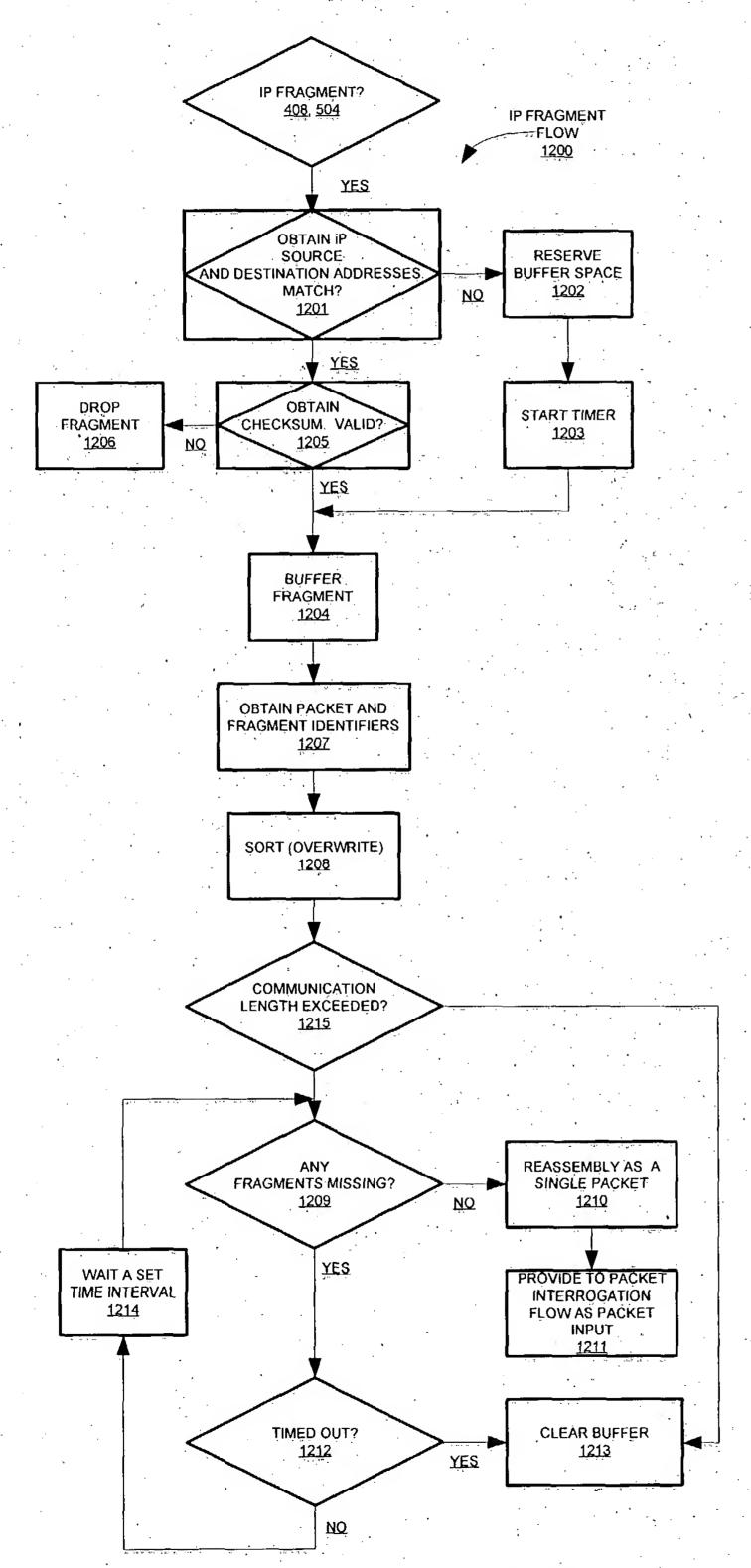Express Mail No.:   EV 324942700 US
Page 25 of 25
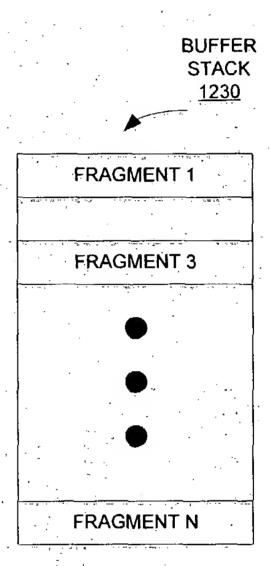
IP FRAGMENT?
408, 504

IP FRAGMENT
FLOW
1200

YES

OBTAIN IP
SOURCE
AND DESTINATION ADDRESSES
MATCH?
1201

NO

RESERVE
BUFFER SPACE
1202

YES

DROP
FRAGMENT
1206

NO

OBTAIN
CHECKSUM VALID?
1205

START TIMER
1203

YES

YES

BUFFER STACK
1230

BUFFER
FRAGMENT
1204

OBTAIN PACKET AND
FRAGMENT IDENTIFIERS
1207

SORT (OVERWRITE)
1208

FRAGMENT 1

FRAGMENT 3

•
•
•

FRAGMENT N

FIG. 17

COMMUNICATION
LENGTH EXCEEDED?
1215

ANY
FRAGMENTS MISSING?
1209

NO

REASSEMBLY AS A
SINGLE PACKET
1210

YES

WAIT A SET
TIME INTERVAL
1214

PROVIDE TO PACKET
INTERROGATION
FLOW AS PACKET
INPUT
1211

TIMED OUT?
1212

YES

CLEAR BUFFER
1213

NO

FIG. 16